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INDUSTRY TERMS OF REFERENCE

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ABSTRACT

An alternate title for this presentation is Tools for the Trade. A brief review of daily operations in the Airline business will be made with emphasis on the decisions made by pilots and the information used to make these decisions. Various wind shears will be discussed as they affect these daily operations. The discussion of tools will focus on airborne reactive and predictive systems. The escape maneuver used to fly out of a severe windshear will be described from a pilot's point of view.

## Session I. Airborne - Terms of Reference

### Tools of the Trade, Wally Gillman, American Airlines

To all of you here, I would like to say, it's a privilege to be able to talk to you today and also very much a challenge. Listening to the previous speakers, I could agree with several things that they've said, first of all, Dave Johnson talked about this being a system problem. That very much is and that's going to basically be the thrust of my presentation, although I say it in different words. Roland said I would have the opportunity to articulate operational requirements. I don't even know what articulate is, so I'm going to have a difficult time there and Herb talked about this meeting being in three phases, hazard characteristics, sensor development, and ground systems, and since we're starting off at the beginning, I guess I'm part of the hazard characteristics.

Let me talk a little bit about myself because I will be referring to some personal experiences here as I go through. I'm a Captain with American Airlines, been flying for over 21 years with American, and about 30 years all together. Seventeen years of that flying was on the line, where day after day after day we'd go out and fly in various weather conditions. For the last 3 1/2 years, I've been a Manager of Flying Engineering for American, which means that my job is to interface with such people as yourself to try to define what our needs are, to try to help develop some equipment. I do test flights, new equipment and new airplanes and when we have certification requirements, then I represent the FAA in certification flights of equipment on our airplane.

Originally, this presentation was supposed to be called Industry: Terms of Reference. That was a little scary to me, so I asked if we could change that and actually the title

now is "Tools for the Trade." Tools for the Trade, and first of all, before I talk about some of these tools, let me talk a little bit about the trade. This viewfoil represents the magnitude of the daily operations of commercial airplanes in the United States in 1987. 6.5 million commercial airline flights. Almost 18,000 daily flights. A little perhaps, personal note, on Sunday the 16th of October, American Airlines flew 231 million revenue passenger miles. That's an awful lot of operations and an awful lot of people travelling an awful lot of miles. I think the point that I would like to make here is that we do this daily, every day and we do it in rain or shine, wind shear, weather conditions, etc. Now, all of you, in this group, are very familiar with wind shears but we tend to focus on microburst quite a bit, but there are all kinds of wind shears that we encounter every day. Almost every one of these flights encounters some kind of wind shear. And a lot of these types of wind shears have caused accidents. A long time ago, an American Airlines airplane hit the dike at La Guardia, Runway 31. That shear is probably due to physical obstruction. And, years ago, going in the midway airport, we always used to have to be careful of the wind shear because of the hangers and the buildings, so those are physical obstructions. We go places where we have wind shears continuously, like in Amsterdam. These types of things are daily occurrences. They're serious. Some of them can be very serious as Roland pointed out in his slide, and we have to take them seriously. But we deal with these things on a daily basis and we need the tools to deal with these things.

If you'll allow me, I'd like to make a few personal references, to talk a little bit about some daily decisions because I think it's important that you understand how we use these tools in daily operation of 18,000 flights a day. Not long ago, as a matter of fact on the 23rd of September, I flew a flight from Chicago to Dusseldorf, Germany, and that particular day, there was a line of storms. So I got on the telephone and talked to the dispatcher. We agreed on a little different routing, adjusted the fuel, and off I went and didn't have any problems. We went through to Dusseldorf with no

problem. The point is, I used some available tools. We used satellite weather depiction, we used weather reports that we had available. We used some radar returns that we had available and we made some decisions. Now, as a result of that we had a non-occurrence. That doesn't mean to say that that event wasn't out there. I know a lot of people out there are concerned when we talk about forward looking sensors, about the fact that by the time you get there the event might not be there, it might be related to a false alarm or something like that. Well in this case, there was no event that I wasn't concerned about a false alarm, I had a smooth trip. Also, about six weeks ago, I flew with a fellow from NASA Langley here, whose name is Charlie Knox, I'm sure Roland knows Charlie. Charlie's got a project on data link, and so I flew him on a Boeing 767 and we went from Dallas to Dulles and I was demonstrating the data link. Now on this particular trip, we rolled out on course and right in front of us was a thunderstorm which was painted on the weather radar. I said to Charlie, "Well, we're going to have to deviate around this thing, but let's take our time, let's look at what's developing on either side of that storm and beyond that storm so we can make our decision in which way to deviate." So we looked at the scope, evaluated the radar returns, and eventually I deviated left. We ended up deviating for about 250 miles and finally went through the hole and went on to Dulles. Again, a smooth ride, a non-event. But I used the tools that were available to make that decision. About a month ago, I was flying a Boeing 767 at Moses Lake, Washington, on a test flight. Part of that test is to fly autoland approaches. We came into Moses Lake and ahead of us was a 747. Now, a 747 is a huge airplane that creates a lot of vortices, and sure enough as we got down on final approach, we started encountering quite a bit of, what you might term as turbulence. The airplane shaking around. We decided to go around rather than continue that approach because we didn't feel the automatic system would be able to handle the shear turbulence conditions as we were encountering them. So that was a decision based upon actually

encountering something, not having any idea of the magnitude that was at the front of us, but not be willing to continue on into it.

Now, those are very recent things, but let me talk a little bit more about something very pertinent to what we're going to talk about here. About one week after Delta 191 accident in Dallas, I was taxiing out to take off on Runway 17 right at DFW Airport. Everybody was very conscience of wind shear after that accident. I remember there was some storms coming in from the northwest and we were watching it as we were in a line of airplanes waiting to take off. We looked at the wind socks. We were listening to the tower reports from the LLWAS system, the winds at various portions around the airport. I was number 2 for take off and I said to my co-pilot, "I'm not going to go on this runway." But just at that time, the number 1 crew in line, Pan Am, said, "I'm not going to go." Then the whole line said, "We're not going to go" then the tower taxied us all down the runway, took us about 15 minutes, down to the other end. By that time the storm had kind of passed by and we all launched to the north. We were using the tools to make those decisions. The tools that we had available. That's the kind of thing that goes on daily. One other example where I wish I had a tool, this is back in the 70's, I was flying co-pilot to Charleston, West Virginia. Now that airport sits on top of the mountain and it's kind of a short runway. You don't like to land with too much speed because you could run off the far end. On the approach, to the runway, you're coming over a great big valley and on that approach, I noticed that the power was way back at idle, very much reduced from what it normally would be. So we discussed the fact that we must have a tail wind at that point, but the tower was reporting a cross wind at the runway. A cross wind almost at our maximum for the airplane, which was a Boeing 727, so we discussed the fact that we better carry a little extra air speed because we were going to encounter a shear. I sure would like to have had a forward looking device so that we could have told how big that shear was going to be. But we carried 25 knots extra airspeed,

which, when you're looking at a short runway on the top of a mountain, is an awful lot of airspeed to carry. Well we got there, and I would say, it felt like two seconds we lost 25 knots. Just like that. I dropped the wing down and just barely saved the landing. We had a reasonable landing, rolled out, and went to the terminal. Nobody knew anything about it, except the guys in the cockpit. I could have used a forward looking sensor for that particular situation.

I've taken quite a bit of time to talk about myself, let's talk about these tools for the trade. I would like to make a little quote from Aeroline, which is a newsletter that's published by ARINC Radio for the AEEC. This is in from the chairman's corner. It says, "We engineers are notorious for becoming entranced with technology for what it can do rather than for what we need it to do. And why? Our industry cannot afford and will not tolerate such a attitude." I'm glad an engineer said that rather than me, you know.

We have some valuable tools coming along. The first one is some valuable training tools that have been developed over the last couple of years as a result of the FAA and industry working on understanding wind shear and particularly microburst. Bob Ireland was involved with this group. They came up with a authoritative training aid that we have used to make changes in our training recently. This is very valuable in our ground training. We are much more aware of the conditions that create microburst and the things to look for that we might be able to detect it and avoid it. In our simulator training, we have microburst models and wind shear models and we have our pilots fly through various wind shear scenarios, practicing detection, detecting when the wind shear is occurring, and then practicing an escape maneuver. Now, we talked about having an unstable approach. When you have an unstable approach, it's time to execute an escape maneuver.

Let me tell you folks, this escape maneuver is not a very nice thing. So let me talk a little bit about escape maneuver. It's something that I don't want to be in if I can avoid it. First of all, when you look at the pilot procedures, they seem pretty straight forward. Use maximum power, rotate to 15 degrees at pitch attitude and then control the flight path. That doesn't seem very difficult, but let me tell you, that is an extreme maneuver from the standpoint of pilot technique. You are operating at a region which you normally don't operate in and it's not something that I want to get involved with if I can avoid it. As far as controlling the flight pass, generally we're talking about stopping a sink so we don't lose altitude and eventually, if you trade off enough air speed in order to stop this sink, you're going to be approaching the limits or stick shaker and you have to respect that and not go into the stick shaker. Well, I would like to take a minute to talk about this escape maneuver. I don't know how many pilots we have in the audience but I would like to take it out of the airplane environment and discuss it from a different perspective. First of all, what is wind shear? Wind shear, I have characterized as stepping off a moving sidewalk like at DFW airport. What happens is that the top part of the body continues to go forward at the same speed but all of a sudden the legs are slowed up because they are no longer on the moving sidewalk. So that's basically the same as wind shear. That's something we can understand and the same affect happens to an airplane. Now, we're dealing with something called angle of attack. And I don't want to get into aerodynamics but, I need to show you what angle attack is before I can continue. (Slide of airfoil at high angle of attack) Here we have an airfoil section, a section through a wing, which the airplane is pointed horizontally. But the airplane is actually going down this path here so that the relative wind is up in that direction. So what we have here is the angular difference between the attitude of the airplane and the flight path of the airplane, this is the angle of attack at that airfoil. When this angle attack exceeds a certain amount, you get over the top surface of the wing instead of getting laminar flow. You lose the lift from the top of the wing and then the airplane

is going to come down! Plain and simple. Particularly if you're in the midst of an escape maneuver in which you already have maximum power. The only way to recover is to lower the nose a little bit, reduce the angle of attack, get laminar flow over the wing and try to fly out. All right, that's all I'm going to talk about angle of attack. Now let's go back to my moving sidewalk analogy. We're going to put a guy on a treadmill (Slide of man on treadmill tilted at steep angle with rear (low) end in the water and net accross high end) Normally the guy moves right along, and there are no problems. He's got lot's of treadmill between the bad water down here and this bad condition up here (net) which represents stick shaker conditions and the end of the treadmill where stall would occur and the guy would fall off. So this guy just marches along doing his thing. But now when we get into wind shear and he's doing the escape maneuver, he gets into a very critical situation where he doesn't have very much to play with. (Slide - similar to previous slide except very little distance between the water and the net) He is very close to disaster down near the water and disaster up near the net and the end of the treadmill. Now we're going to turn the lights out so he can't see how close he is to this stick shaker (net) because there's nothing in the cockpit of older airplanes that shows you where stick shaker is. So our guy is going blindly along hoping that he won't get into the net and hoping he is doing enough to keep from falling into the water. Now, no only am I going to turn the lights out but I'm going to simulate up drafts and down drafts by changing the pitch of the treadmill up and down. Now our guy is going around in the dark trying to stay in this little bit of treadmill while it is pitching up and down. That's kind of like an escape maneuver. It's not a maneuver I want to have to accomplish.

Another valuable tool is the airborne reactive wind shear system that has been under development for a number of years. Bob Ireland and I have been working on an S7 committee of SAE, trying to define the operational characteristics of such a system. It's a reactive airborne system like I fly on the Boeing 767 right now. It is a very



useful tool. We are able to reinforce what we are seeing in the cockpit with this detection alerting system. It reinforces the fact that we're in trouble and that it is due to wind shear. You know, a lot of times there can be turbulence and as I said earlier, day after day, after day, after day we operate into weather conditions where we have shears, we have turbulence, we have deterioration of flight path, and we counter those conditions and continue operating. Now all of a sudden, we've got a device to help us recognize when this shear is beyond the normal limits and annunciates "wind shear" and provides us with flight director guidance for the escape. This is kind of like putting a meter in front of the guy on the treadmill so he can march at the right rate, and stay on the treadmill. So far, we've been doing a pretty good job with this new training program that we've got. They do an excellent job of recognizing the different tilts of the treadmill and marching at the right pace even without this flight director guidance.

I think in terms of time, the next systems that are going to be operational use will be ground based systems. In fact, LLWAS is already in operation. We're going to have some discussions about further development of that tool and development of the terminal doppler weather radar later on in this symposium.

These are exciting tools, but what I would like to focus your attention on is this bottom bullet on my viewfoil where I get back to what Dave Johnson said earlier, in that it's a system problem. You've got to present information to the crew in such a manner that they can utilize the information. When we talk about what happened in Denver on July 11, I'd like you to remember this because there was information there that the crews did not receive the information in a manner that they could operate on it. So if you could just keep this in mind during those presentations, I think that's the kind of thing .. kind of message I'd like to get across. The big thing, as far as I'm

concerned is that the devices on the ground, ought to be able to give us enough information and I can avoid ever getting to that escape maneuver.

The next tools down the line are the tools that are going to come out of all the work that's being done here in airborne sensors. Again this is exciting to have the work that's being done here. We see (we being operational guys in the S7 committee) see this falling into two categories. One set of sensors or some early technology might give us early detection and early escape and the earlier you escape the more treadmill you've got to work with, you know, so the less dangerous that escape maneuver is. Again, though, what we really need to aim at is to have enough information that we can avoid the problem. In case I haven't made my point yet, I just have one viewfoil that might emphasize it. (AVOID, AVOID, AVOID IN LARGE LETTERS) That's what I'm aiming at. Now, what are the characteristics of an avoidance tool. Remember, this has got to be a systems development. We've got to work on these tools to present the information so that we can use it. I see them as having some kind of a situational display that is easy to interpret. I don't have to spend a lot of heads down time. I don't have to spend a lot of manipulative time. I don't have to work a lot of dials. It's a minimum workload. I'm already in an environment during take off or during approach where the workload is heavy. I've got to have something that is very useful for me. I've got to have time or distance (you know we're travelling 3 to 4 miles a minute) I've got to have time to come to some decision and try to coordinate that decision with air traffic control and then I've got to have information that allows me to pick an avoidance path to get out of this environment so that I can avoid it all together. So those are the ingredients I think and characteristics of an avoidance tool.

Thank you very much.